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The Properties of Coke Breeze Briquettes Produced by Ram Briquetting

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Abstract. The paper reports on the results of briquetting coke breeze with a binder in a closed cylindrical press-die. Liquid glass is used as a binder. Approximating curves for the “compaction ratio vs. compaction pressure” dependences are plotted from experimental data. The mechanical properties of the briquettes are determined, namely, drop damage resistance and breaking stress. The results are presented as approximating dependences in the form of a power function.

INTRODUCTION

The process of producing total coke for ferrous metallurgy has wastes in the form of coke breeze and dust. The yield of coke breeze in production amounts to 5÷7%. The use of these wastes directly in pyrometallurgy is complicated by the problem of the exportation of light particles from the furnace space by convective flows [1]. In this case there is a universal way of solving the engineering problem, which consists in the procedure of particle coarsening to an acceptable size with the application of various pelletizing methods, the briquetting method being prominent among them.

In some studies, e.g. in [2], it was proposed to use the wastes from the production of total coke in foundry engineering to heat cupolas. In this case there even was a positive effect consisting in a 10÷15 ^{o}C increase in the temperature developed by cast iron in comparison with feeding the same quantity of coke [3]. It was reported that the problem of utilizing coke breeze is an environmental problem facing the metallurgical industry. Coke breeze can also be used as a domestic fuel and as a fuel for zinc production and sintering of nickel ores.

The problem of producing coke-containing briquettes is being actively solved abroad, e.g. by roll pressing [4], and composite briquettes containing iron oxides [5], including in the form of scale [6]. It was proposed in [7] to make briquettes for ferroalloy industry by extrusion. The Siberian State Aerospace University, the Eastern Research Coal Chemistry Institute, the NKP Tekhnologiya LLC and the Institute of Ferrous Metallurgy of NAS of Ukraine [8, 9] are known to have an experience in producing fuel briquettes from fines, including coke breeze, by ram and roll pressing with a binder (lignosulfonate, alkali solutions, tarry wastes of coke and by-product processes, molasses, etc.).

EXPERIMENTAL PROCEDURE

We made investigations of ram and roll pressing (briquetting) of coke breeze with the aim of selecting parameters for the preparation of furnace burden for briquetting and briquetting proper [10–12].

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Experiments were made in the laboratory of the Chair of Metal Forming at the Ural Federal University on a UIM-30 multipurpose test machine with a nominal force of 300 kN in a closed cylindrical die by unidirectional compression. Cylinder-shaped briquettes were produced, with the diameter D=40.4 mm and the height H=18 mm. A scheme of briquetting in a closed die is shown in Fig. 1*a*. The briquetting device (4) consists of a closed die (2) and a base (3). Briquetting is performed by a ram (1). The arrow in the figure shows the direction of compression.

Coke breeze was compacted (according to Specification 0763-199-00190437-2004 *Coke Breeze*), the particle size being 1 to 6 mm. Different binder contents was used, liquid glass $Na_2O(SiO_2)_n$ with a density of 1.47 g/cm^3 (according to GOST 13078-81 *Sodium Silicate Solute. Specifications*) being used as a binder.

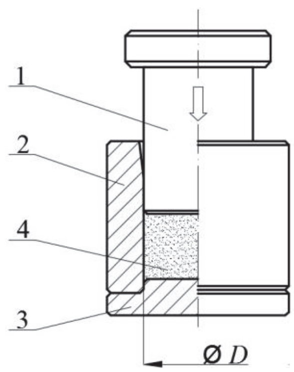
The bulk density of the coke breeze without the binder was 0.92 g/cm^3. When the binder was introduced, the original mass acquired lower bulk density – about 0.5 to 0.6 g/cm^3. The burden was prepared by mixing in a laboratory mixer.

Compaction curves for briquetting prepared burden consisting of coke breeze with 5.0, 7.5 and 10.0 wt% of liquid glass as a binder have been determined. The dependences of the compaction ratio on compaction pressure, with different contents of the binder, are shown in Fig. 1*b*.

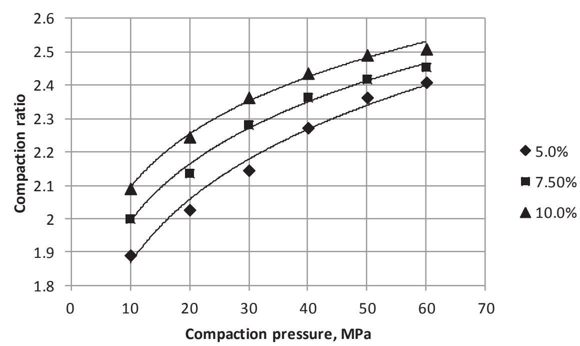
The compaction ratio is determined from the mass constancy condition in view of the constancy of the cross section area of the specimen by the formula

$$k_i = \frac{\rho_i}{\rho_0}\,, \tag{1}$$

where ρ_0 and ρ_i are, respectively, the initial and current material densities.

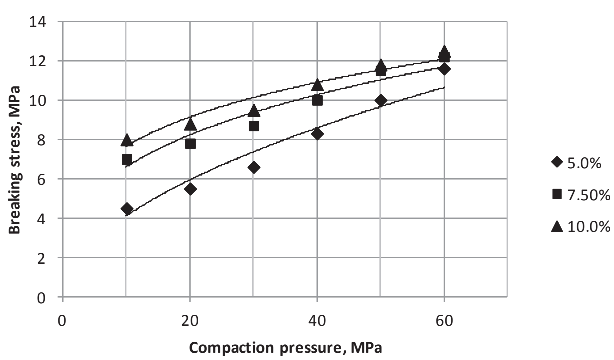


(*a*)

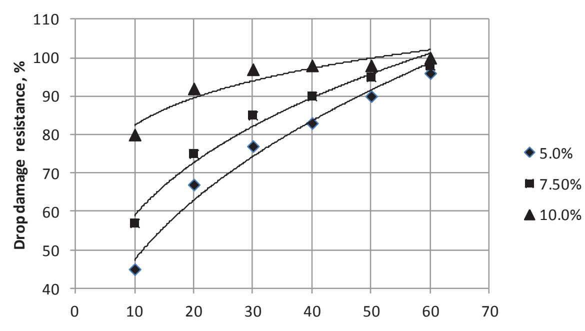


(*b*)

FIGURE 1. A scheme of unidirectional briquetting in a closed die (*a*) and the dependence of the compaction ratio on compaction pressure (*b*)



(a)



(b)

FIGURE 2. The dependence of the breaking stress (*a*) and drop damage resistance (*b*) of the briquettes on compaction pressure

The briquettes were dried at 100 °C for 2 hours. Having received a batch of briquettes, we determined their strength characteristics (3 briquettes per each point on the plots), such as

- drop damage resistance (according to GOST 25471-82 Iron ores, concentrates, agglomerates and pellets. Method for the determination of solidity on droption);
- breaking stress (according to GOST 21289-75 Coal briquettes. Methods for the determination of mechanical strength).

The calculation results (regression lines) are presented in Fig. 1*b* together with the experimentally measured values of the compaction ratio. The regression lines are approximated by the equation

$$k = Ap^n, \tag{2}$$

where p is compaction pressure, MPa; A and n are regression equation coefficients.

The regression equation coefficients for the compaction curves, as well as the determination coefficients R2, are reported in table 1.

Figure 2 presents curves showing the dependence of drop damage resistance on compaction pressure and binder content. The regression lines are approximated by Eq. (2). The regression equation coefficients for the strength curves, as well as the determination coefficients R^2, are shown in tables 2 and 3.

TABLE 1. The regression equation coefficients and the determination coefficients R^2 for Fig. 1*b*

Liquid glass content, %	Coefficient A in equation (2) , MPa	Coefficient n in equation (2)	R^2
5.0	1.6409	0.1058	0.9940
7.5	1.5134	0.1193	0.9917
10.0	1.3506	0.1404	0.9833

TABLE 2. The regression equation coefficients and the determination coefficients R^2 for Fig. 2*a*

Liquid glass content, %	Coefficient A in equation (2), MPa	Coefficient n in equation (2)	R^2
5.0	18.4050	0.4100	0.9763
7.5	29.4660	0.3012	0.9781
10.0	62.5880	0.1194	0.9000

TABLE 3. The regression equation coefficients and the determination coefficients R^2 for Fig. 2*b*

Liquid glass content, %	Coefficient A in equation (2), MPa	Coefficient n in equation (2)	R^2
5.0	1.2098	0.5307	0.9452
7.5	3.1572	0.3193	0.9325
10.0	4.2567	0.2544	0.9395

RESULTS AND DISCUSSION

With a binder content of 5% and a compaction pressure of 60 MPa, it is possible to achieve a drop damage resistance of 97%. At the same time, with a binder content of 10%, the same result is achieved at a compaction pressure of 30 MPa. Note that lower compaction pressure in an industrial process leads to the higher wear resistance of the equipment.

The test results demonstrate that the strength of briquettes increases with the binder content. However, the effect of this increase subsides as the binder content grows. When the value of compaction pressure reaches 60 MPa, the result obtained on breaking stress stops depending on the binder content. Understandably, under industrial conditions, it is desirable to use the lowest possible binder quantity, since excess binder content causes additional expenditures. Therefore, it is expedient to choose the binder content amounting to 7.5% and the compaction pressure amounting to 50 MPa. The further increase in both compaction pressure and the binder quantity does not increase breaking stress considerably.

If one is guided by the requirements to blast-furnace burden, they specify the use of lump materials with strength ranging between 5.8 and 10 MPa. It is obvious from the graphs that these values of strength are quite attainable with the use of the tested briquetting conditions.

CONCLUSION

Thus, the experiments on compacting coke breeze enable one to make calculations and design processes and equipment for the actual output of a production line. The utilization of coke production wastes provides an additional power source for industrial production.

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